BRIEFER ARTICLES

EVIDENCE FOR THE GENERAL DISTRIBUTION OF OXIDASES IN PLANTS

If the oxidases play the essential rôle in respiration which recent theories have attributed to them, they must be present in all living cells. Two types of tissues, however, have been reported to be without oxidases, namely, tissues markedly acid in reaction and some tissues said to contain large amounts of reducing substances.

Recently it has been pointed out by the writer[1] that in some of the most acid plant tissues, the citrus fruits, the reported absence of oxidases was due to the methods of investigation. By separating out the carpel sacs in such a way that the acid juice and the ferment were kept apart, as is normally the case in the living tissue, good oxidase reactions were obtained; whereas in former methods the tissue was ground in an attempt to extract the ferment, and the latter was then inhibited by the action of the acid.

Tissues reported to be free of oxidases on account of the presence of reducing substances include a few organs of some higher plants and the algae as a group (with but two definite exceptions), so far as they have been investigated.[2]

Examining a few representative forms from the algae with a number of reagents, results as indicated in the accompanying table were obtained. The material was freed from foreign matter as far as possible, ground, or in the case of the large brown forms simply torn up and added to the solutions of the reagent. The formation of oxidation products was then followed by color changes as compared with checks containing boiled material.

The results indicated in the table were further confirmed in the case of the filamentous forms by following the reactions in individual cells. The material was placed in a one-half per cent watery solution of paraphenylenediamine, or equal parts of one-half per cent solution of paraphenylenediamine and alpha napthol (Spitzer's reagent); and in each

[1] BOT. GAZ. **57**:528. 1914.

[2] ATKINS, Sci. Proc. Roy. Dublin Soc. **14**:11; DUGGAR and DAVIS, Science N.S. **39**:260. 1914.

case sufficient hydrogen peroxide to make the concentration 0.1 per cent. Results were similar in the two cases. In from one-half to ten minutes the oxidation products appeared in the form of minute dark granules exhibiting slow Brownian motion and distributed throughout

TABLE I

THE OXIDATION OF VARIOUS COMPOUNDS BY HYDROGEN PEROXIDE WHEN ACTIVATED BY JUICE EXPRESSED FROM LIVING ALGAE: (+) INDICATES A POSITIVE REACTION IN TEN MINUTES OR LESS; (−) INDICATES NO REACTION EVEN AFTER SOME HOURS OR ONE TOO FAINT TO BE CONSIDERED TRUSTWORTHY.

	Gum guaiac	Pyrogallol	Hydrochinone	Alpha napthol	Alpha napthol and Para-phenylenediamine	Para-phenylenediamine	Alpha napthol and Para-phenylenediamine hydrochloride	Para-phenylenediamine hydrochloride	Benzidine	Aloin	Phenol	Para-cresol	Sodium selenite
Blue-green													
Oscillaria sp...	−	−	−	+	+	+	+	+	−	−	−	−	−
Green													
Conferva sp....	−	−	−	−	+	+	−	−	−	−	−	−	−
Spirogyra sp...	−	faint	faint	−	+	+	+	+	+	−	−	−	−
Ulva sp.....	+*	+*	+*	−	+*	+	+	+	+	faint	−	−	−
Enteromorpha sp.....	−	−	−	−	+	+	−	−	+	−	−	−	−
Chaetophora sp.	−	−	−	−	+	+	+	+	+	−	−	−	−
Vaucheria sp...	−	−	−	−	+	+	+	+	+	−	−	−	−
Chara sp.....	−	−	−	−	+	+	−	−	−	−	−	−	−
Brown													
Laminaria saccharina.....	−	−	−	−	+	+	+	+	+	−	−	−	−
Fucus sp.....	−	−	−	−	+	+	+	+	+	−	−	−	−
Ascophyllum nodosum.....	−	−	−	−	+	+	+	+	+	−	−	−	−
Red													
Chondrus crispus.....	−	−	−	−	+	+	−	−	+	−	−	−	−
Polysiphonia sp.	−	−	−	−	+	+	−	−	−	−	−	−	−

* Reaction with and without hydrogen peroxide.

the protoplasm. The size of the granules varied slightly in different species, but in all cases granules were found only in the protoplasm, never in the vacuole. In *Vaucheria* (and occasionally in *Spirogyra*) they showed a tendency to aggregate about the nuclei, though never about the chromatophores. In cells which had been boiled, however,

though the structure of the cell had not been seriously affected, no granules were formed, since the boiling had destroyed the ferment.[3]

An examination of the results summarized in the table shows that, so far as one is able to judge by color changes, the algae as a class possess a ferment capable of activating the oxidation of a limited number of compounds. In other words, it appears that this ferment is specific in its action. The condition is not surprising, inasmuch as it is characteristic, to a greater or less extent, of all ferments and has many parallels among the oxidases themselves.

From the uniformity of results with the forms examined, it is apparent that the oxidases are of general occurence among the algae. These, and the writer's observations on acid tissues, indicate that the oxidases are universally distributed in living plants, and that other cases of their apparent absence may be explained in ways similar to those herein discussed.—G. B. REED, *Laboratory of Plant Physiology, Harvard University.*

[3] A more detailed account of the formation of these granules in plant cells is soon to be published.